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SOME SPRAY DISTRIBUTION AND ATOMIZATION TESTS WITH A HELICOPTER

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SOME SPRAY DISTRIBUTION AND ATOMIZATION TESTS WITH A HELICOPTER[1/]

By D. A. Isler[2/] and Bohdan Maksymiuk[3/]

INTRODUCTION

Both fixed wing and rotary wing aircraft have been used in aerial spraying experiments for control of the white-pine weevil. Results obtained in these experiments have indicated that the downdraft from a helicopter assisted in forcibly driving the spray into the upper whorl of branches of young white pines, and that this helped overcome the screening effect of the foliage.[4/] Since the results of these experiments were not conclusive, it was decided to run additional ones in 1959. In preparation for these experiments, the Beltsville Forest Insect Laboratory was asked to conduct some tests on the distribution and atomization of sprays produced by the helicopter which was to be used in the experimental work. These performance tests were made over open ground at the Beltsville, Md., airport, March 23, 24, and April 1, 1959, and the results are given in this report.

EQUIPMENT

The helicopter used was a Bell 47 D-1 owned by Agrotors, Inc., Gettysburg, Pa. (fig. 1). Thirty-eight Spraying Systems Company D-2-23 hollow cone disc-type TeeJet nozzles were used.[5/] Twenty-four of these were uniformly spaced along the rear side of the 21-foot boom; the remainder were uniformly spaced along the front side of the outboard one-half of the boom. All of them were directed down 90 degrees to the line of flight. A 1-inch centrifugal pump, driven by the aircraft

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1/ Based on work carried out jointly by Beltsville Forest Insect Laboratory Division of Forest Insect Research, Forest Service, and Agricultural Engineering Research Division, Agricultural Research Service, USDA.

2/ Agricultural Engineer, Crop Production Engineering Research Branch Agricultural Engineering Research Division, ARS.

3/ Entomologist, Beltsville Forest Insect Laboratory, Division of Forest Insect Research, Forest Service.

4/ Bean, J. L., McIntyre T., and Smith, W. E. Helicopter Spraying for White-Pine Weevil Control. Unpublished Report. USDA, New Haven, Conn. Dec. 1950.

5/ Mention of trade names or commercial companies does not imply endorsement of any particular product or commercial concern.

engine, provided a continuous spray pressure of 75 to 80 pounds per square inch.

The flow rate of the spray system was 7.7 g. p. m. (gallons per minute). This was about 45 percent faster than the catalog rated discharge for the nozzles indicating considerable orifice enlargement due to erosion. The 7.7 g. p. m. flow rate was the rate required for 1 g. p. a. (gallon per acre) over a 100-foot swath at 38 m. p. h. (miles per hour). There was some leakage at the pump shaft seal for the tests made March 23 and 24. As a result, the pump was replaced prior to the tests of April 1.

Figure 1 - Bell 47 D-1 helicopter.

PROCEDURE

Spray Distribution Tests

In the spray distribution studies, samples of the falling spray were collected on a pair of 6- by 6-inch aluminum plates placed at 5-foot intervals across the swath. This line of sampling plates was laid out at an approximate right angle to the direction of the wind. The spray mixture consisted of 1 pound of DDT, 1 quart of Mobilsol 544B solvent, 0.8 ounce of Calco oil orange dye, and sufficient fuel oil No. 2 to make 1 gallon of finished spray. Captive weather ballons were used for flight direction and height guides.

The helicopter made one spray pass upwind across the center of the sampling line during each flight. After an interval of 10 minutes to allow the spray to settle, the sprayed plates were picked up, placed in

carrying cases, and taken to the laboratory for examination. There, the quantity of spray in gallons per acre at each sampling point was determined by the dye tracer method. From these data graphs were plotted to show the distribution of the spray across the swath. When the angle between the flight line and sampling line was more than 15 degrees from a right angle the sampling interval was corrected to the equivalent right angle distance.

Spray Atomization Tests

Fuel oil No. 2 alone was used in the spray system for the atomization tests. This was done because it had previously been determined that when the appropriate spread factor was applied there was no significant difference in mmd (mass median diameter) between the standard spray mixture described above and fuel oil No. 2. The oil spray deposit samples were collected on 4 1/4- by 5-inch oil-sensitive red-dyed cards. These were also located at 5-foot intervals along a sampling line at right angles to the line of flight of the aircraft. In these tests the flow rate was reduced to about one-fourth the normal rate to minimize the overlapping of drop spots on the red-dyed cards. This increased the accuracy and expedited the measurement of the size of the drop spots.

Captive weather ballons were used for direction and height guides. As in the distribution tests, the helicopter made one spray pass over the sampling line. After an interval of 10 minutes in which the spray was allowed to settle, the sprayed cards were picked up and taken to the laboratory for examination. Spray atomization, expressed as mmd, was determined in two ways: (1) Through measurement, using the proportionate area method [6] and (2) by estimation using the D-max method.[7]

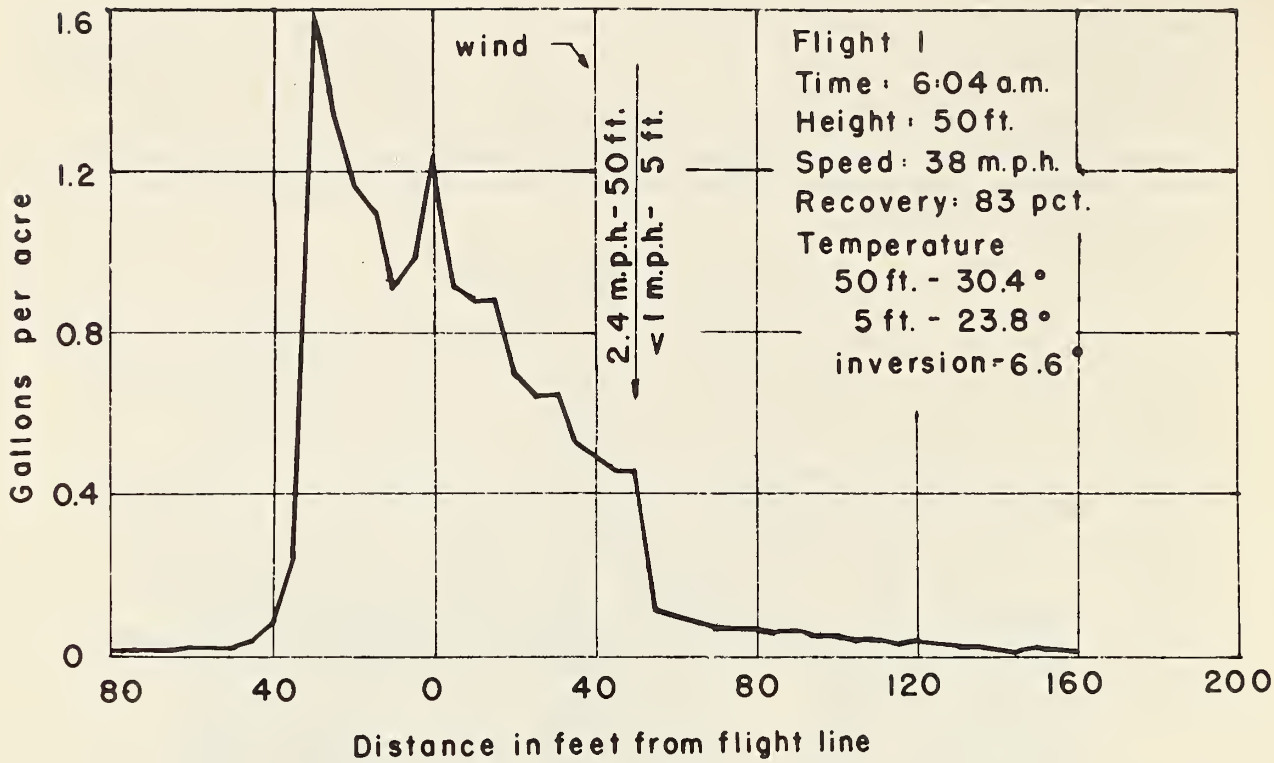
RESULTS

Spray Distribution

Figures 2 to 5 show the pattern of distribution of spray across the swath for the five flights made in this series. Flights 1 and 2 (fig. 2) were made during early morning hours with lower wind velocities, less crosswind, and greater temperature inversions than flights 3 and 4 (fig. 3), and flight 5 (fig. 4), which were made during evening hours. The helicopter was flown at a height of 50 feet for flights 1 and 2 and at a height of 25 feet for flights 3, 4, and 5.

6/ Thornton, D. G., and Davis, J. M. A Method of Sampling for the Drop Size of Aerial Spray Deposits. Jour. Econ. Ent. 49 (1): 80-83, Feb. 1956.

7/ Maksymiuk, Bohdan. A Rapid Method for Estimating the Atomization of Aerial Sprays. (Unpublished manuscript, on file - Division of Forest Insect Research, Forest Service, USDA, Beltsville, Md.) 1959.



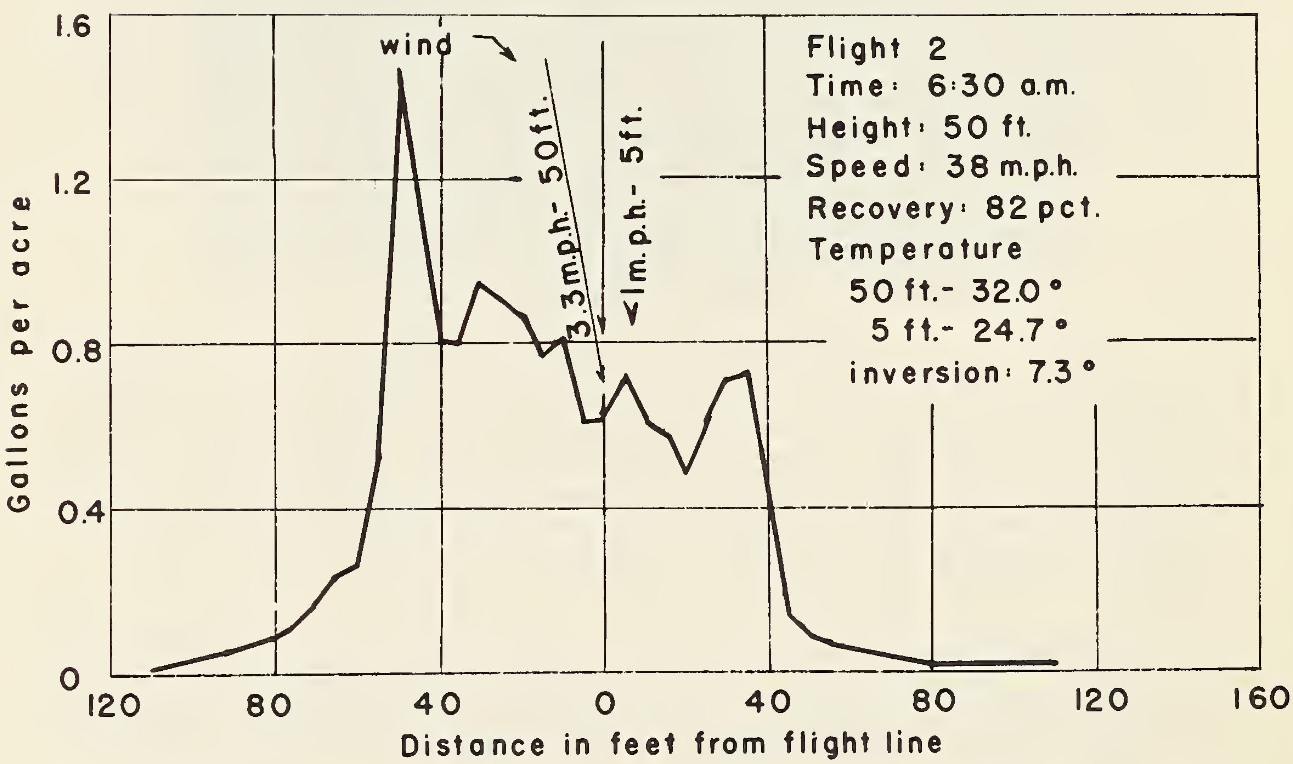
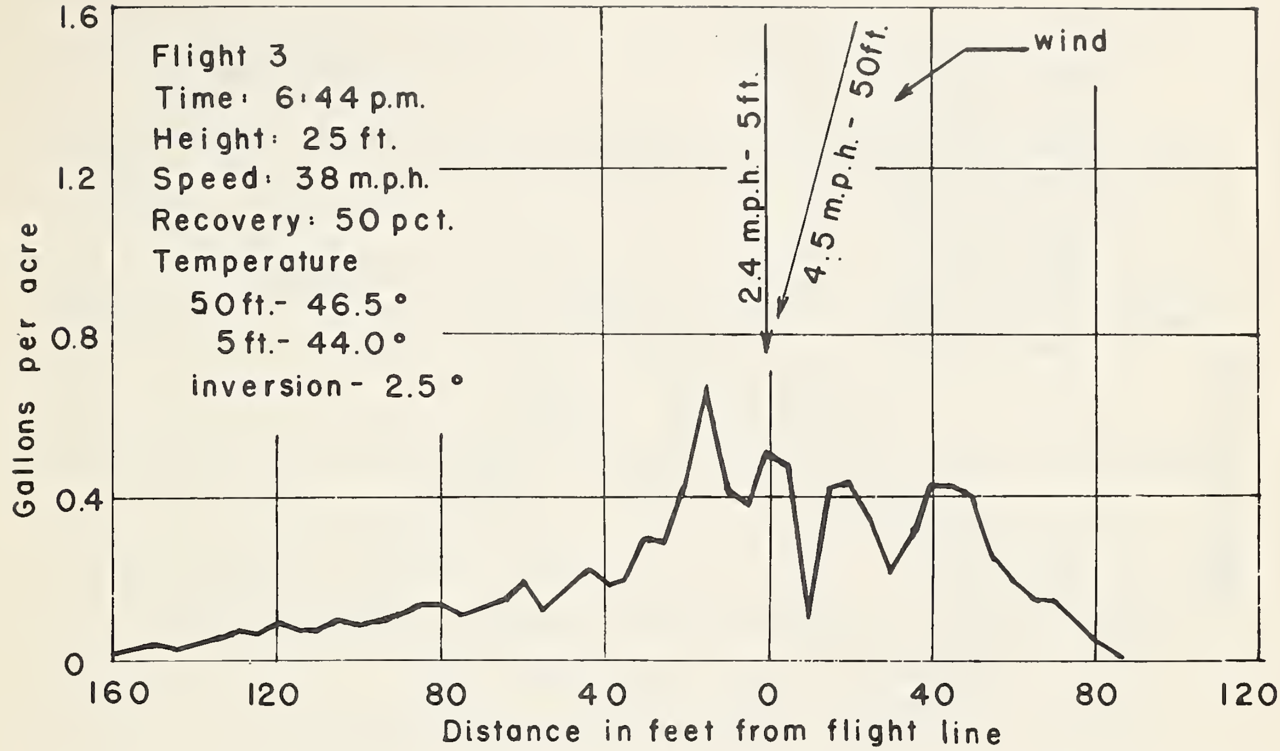


Figure 2 - Spray Distribution: Flights 1 and 2.



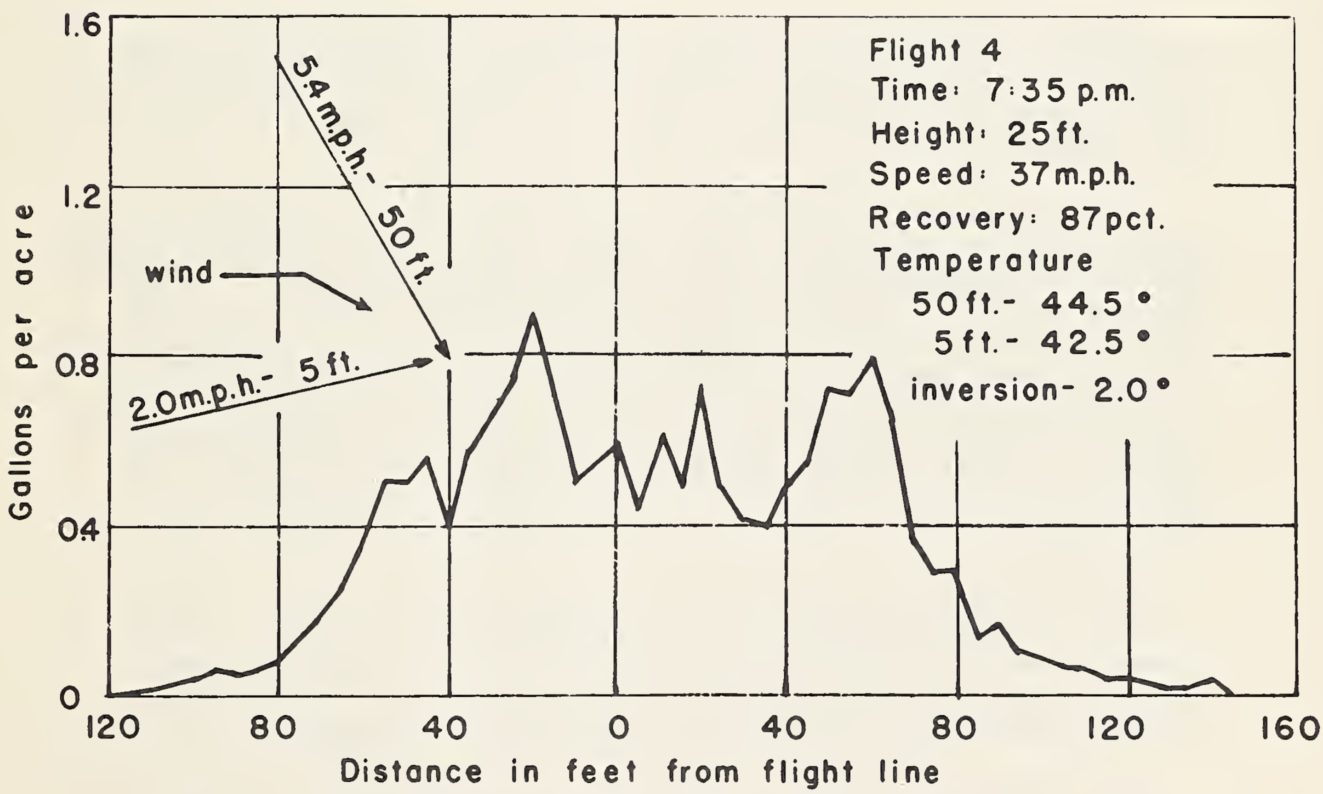


Figure 3 - Spray Distribution: Flights 3 and 4.

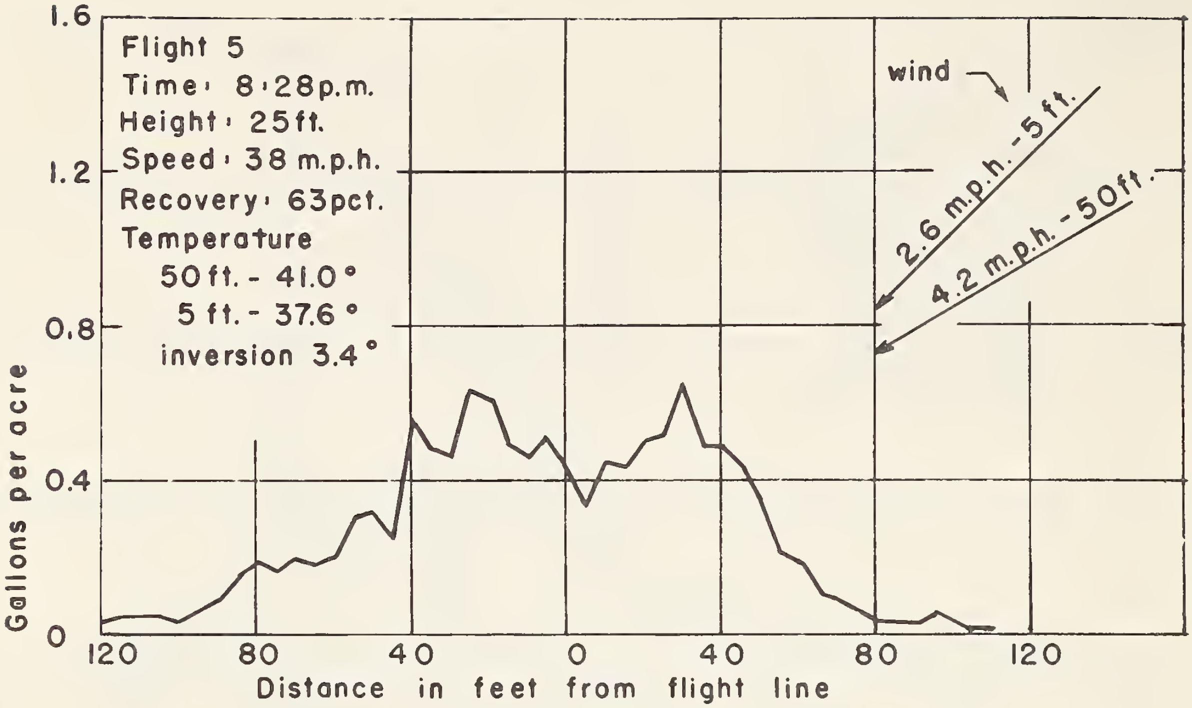


Figure 4 - Spray Distribution: Flight 5.

There are two main differences between the graphs of flights at the two heights. There were much higher peaks of spray deposits 30 to 50 feet left of the center line of flight at the 50-foot height than at the 25-foot level. At 25 feet, the spray was more evenly distributed over a wider swath.

Because of the limited number of flights, it is not possible to pinpoint definite reasons for these differences. One possibility is that when the helicopter was flown only 25 feet above the ground it produced a greater amount of lateral movement of the downwash after it reached the ground than when it was flown at a height of 50 feet, thus resulting in a wider swath and more uniform distribution. It is also possible that the greater temperature inversions and lower wind velocities during the morning flights than during the evening ones may have caused the spray to fall more directly downward. Action of the rotor blades may have been partly responsible for the high peaks at the left of the center lines.

Table 1 shows the width of swath at various spray deposit levels for each of the five flights and the average for all of them. The average spray distribution from the five flights is shown in figure 5. For comparison, the average spray distribution from 17 flights with a Stearman airplane (220 horsepower) is also shown in figure 5.

The percent of the spray released from the helicopter recovered on the ground is shown in table 1. The average for all flights was 73 percent. For flight 3 it was only 50 percent, considerably below the average. There is no apparent explanation for the low rate of recovery from this flight.

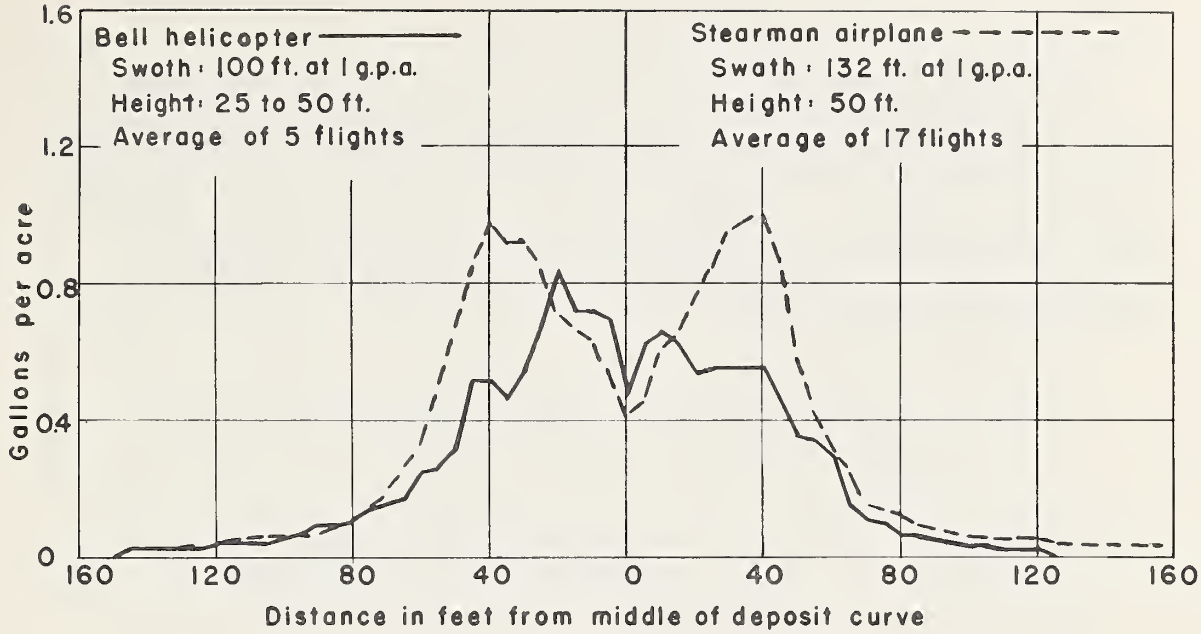


Figure 5 - Comparison of spray distribution by helicopter and airplane.

Table 1 -- Swath width and percent recovery for test flights.

Flight No.	Height in feet	Swath width in feet at --					Percent Recovery
		0.1 g.p.a.	0.2 g.p.a.	0.3 g.p.a.	0.4 g.p.a.	0.5 g.p.a.	
1	50	1/ 100	90	87	85	74	83
2	50	125	110	99	96	92	82
3	25	169	96	63	41	8	50
4	25	173	152	137	127	93	87
5	25	155	121	98	82	38	63
Average		144	114	97	86	61	73

1/ Distance across swath in which deposit rate was not less than that shown in column heading.

Spray Atomization

Four flights were made on March 24. As previously mentioned, there was some leakage at the pump shaft during these tests, therefore, a true drop spectrum was not obtained. After the pump packing had been replaced, two flights were made on April 1 and the results are shown in table 2. A measured mmd of 137 microns and an estimated mmd of 144 microns were obtained. This is within the "medium" atomization range delivered by fixed wing spray planes employed on forest insect control jobs.

Table 2 -- Spray atomization test flights.

Flight Number	Mass median diameter	
	Estimated	Measured
	microns	microns
1	147	130
2	141	144
Average	144	137

DISCUSSION

The swath pattern tests indicate that at heights of 25 and 50 feet the Bell 47 D-1 helicopter covered swaths about 100-foot wide at deposit rates of 0.25 to 0.3 g.p.a. The distribution was more uniform than that generally obtained by a fixed wing aircraft. In all of the flights there was a tendency toward a bimodel distribution of the spray; but this was not so evident as when fixed wing aircraft are used. Records from two flights show that the swath was not displaced downward to any great extent by crosswinds of 2 to 2.6 m.p.h. 5 feet above ground. Thus, these winds had less effect on swath pattern than would have been the case with a fixed wing plane.

The leakage at the pump shaft probably had very little effect on swath pattern. The 73 percent average recovery was about the same as that which has been obtained from fixed wing spray planes. The drop size data in table 2 are considered reliable for the particular nozzles on this aircraft. Because the orifices of the nozzles used in these tests were enlarged due to erosion, the mmd of the spray may not have been the same as when the nozzles were new.

The results of these tests, together with those of earlier field trials, clearly demonstrate the potential advantages of the helicopter as a tool in forest insect control, particularly for spraying small areas. Compared to light airplanes, the helicopter not only lays down a more uniform spray swath but the slower speed and higher maneuverability also permit a more uniform coverage areawise.

At present the high operating cost limits helicopter operation to high value areas such as Christmas tree plantations. With the constantly growing demand for increased production from small forest holdings, however, we can expect a corresponding increase in the use of the helicopter for their protection. But before the potential advantages of the helicopter can be fully utilized, we need much more information on the effect on distribution and coverage of such factors as height of flight, airspeed, and spray atomization or particle size of the material applied. Such information is basic to developing efficient dispersal apparatus that will put the material, whether sprays, dusts, or granules, where it will be the most effective for the particular insect to be controlled.

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